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Fig. 1. Spraying Tomatoes for Leaf Blight

DISEASES OF TOMATOES

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DISEASES OF TOMATOES[1]

Tomato growing is one of the very important agricultural industries in New Jersey. Tomatoes are grown extensively for general market purposes and for the canneries. Like all other farm crops, the tomato is subject to many diseases which reduce the yield and profits. These diseases are the subject of so many inquiries being sent to the Agricultural Experiment Station that we have decided to issue this circular for the information of the growers.

Leaf Blight, Late Blight (*Septoria lycopersici* Speg.)

This is the most important fungous disease of the tomato in New Jersey. It starts in the extreme southern part of the state about July first and gradually moves northward and, therefore, is much more destructive on the late market and can-house crops than on the early tomatoes. It is most destructive in those localities in which tomatoes are grown extensively, especially for the canneries. The average loss has been estimated by the United States Department of Agriculture at $25 per acre and the total loss for the United States at approximately $5,000,000 per year.

The disease starts on the lower leaves, causing small, dark, angular or circular spots. These spots increase in size until about 1/8 inch in diameter and the centers become grayish in color. Eventually small black pimples, which are the fruiting bodies of the fungus, appear in the center of the spots. The diseased leaves turn yellow, curl and become dry and then fall. The disease gradually moves

[1]Prepared, December, 1918, by Mel T. Cook, Ph.D., Plant Pathologist, New Jersey Agricultural Experiment Station, and W. H. Martin, Ph.D., Associate Plant Pathologist, consolidating Circular 71, issued in 1917, and Circular 97, issued in 1918.

upward along the stems, slowly defoliating them. When the disease is well advanced we find very little foliage except at the tips of the stems. This disease also attacks the stems, causing irregular discolored markings. It is sometimes found on the green fruit but is not conspicuous. The destruction of the foliage causes a reduced yield, exposes the fruit to sunburn, and usually results in early ripening.

Fig. 2. First Stage of Leaf Blight. Note the lower leaves (Photo by R. W. DeBaun)

The Spread of the Disease

The fungus is spread from plant to plant by means of its spores (fruit of the fungus) which are produced in the small, black pimple-like fruiting bodies. These spores are so very small that we cannot see them except with the compound microscope. They are produced in great numbers and ooze out of the fruiting bodies in very small sticky masses which dry but are later liberated by the dew and rain. When moistened by the rain and dew they stick to insects, the hands

and clothing of the laborers and the farm machinery, and are readily carried from plant to plant. Insects feeding on these diseased plants very naturally eat a great many fungous spores, which the junior author has demonstrated will germinate very readily after having passed through the body of the insect.

They may also be scattered for short distances by the splashing of the rain-water. When these spores come in contact with the moist surface of the leaf they germinate and start new centers of infection. The disease spreads very rapidly following its appearance in a locality. The fungus is probably carried over the winter on the old tomato plants and possibly in the soil.

Control

Cultivation. (1) The burning of the old plants is sometimes recommended, but many prefer to plow the plants under and get the benefit of the decaying material. (2) Deep plowing which puts this material far enough under to hasten its decay is advantageous. (3) Rotation of crops is also advantageous, especially in communities where the acreage is not so large as to make infection from neighboring fields important. (4) The disease is not so destructive early in the season as it is late in the season. It is also less destructive on vigorous than on weak plants. Therefore, it is advantageous to grow the crop on a rich soil which produces strong, vigorous plants. The disease can be held in check by spraying with Bordeaux mixture (page 11).

Early Blight and Fruit Rot (*Macrosporium solani* E. & M.)

This fungous disease attacks both tomatoes and potatoes. Although called the "early blight," it appears at about the same time as the late blight. It appears as small, black angular spots which increase in size until they are quite large and frequently show concentric rings. It also attacks the fruit, causing small, black spots. It is one of the minor diseases in this state.

It can be controlled by thorough spraying with Bordeaux mixture (page 11).

Late Blight [*Phytophthora infestans* (Mont.) DeBary]

This fungous disease of the foliage and occasionally of the fruit also attacks potatoes. It is of little or no importance in New Jersey, and can be controlled by thorough spraying with Bordeaux mixture.

Anthracnose or Ripe Rot [*Colletotrichum phomoides* (Sacc.) Chester]

This fungous disease attacks the ripe and nearly ripe fruit, causing a soft, rapid decay. The spots may start on any part of the fruit. They are circular, and at first have the appearance of being water-soaked but finally become black. They frequently unite and cause

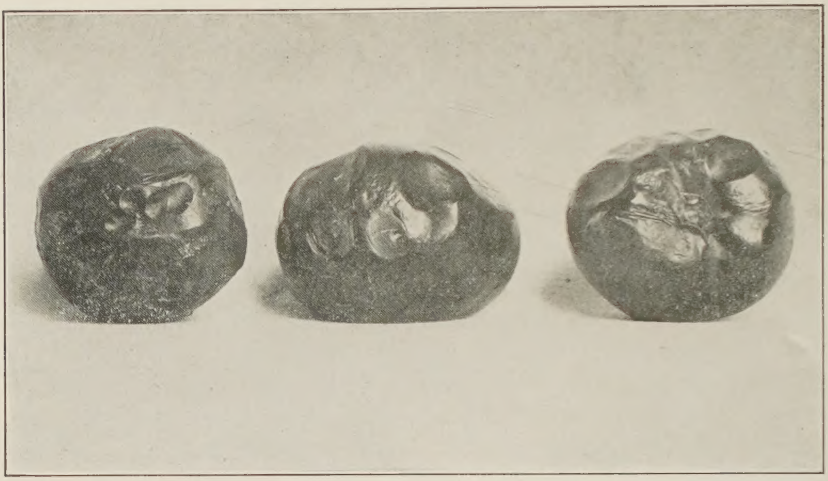

Fig. 3. Anthracnose, or Ripe Rot

irregular rotten areas. It is especially severe on sun-burnt plants that have been defoliated by the leaf blight (page 2) and other causes. The losses due to this disease are very heavy and second in importance only to the leaf blight.

This disease can be controlled by thorough spraying with Bordeaux mixture (page 11).

Leaf and Fruit Spot (*Phoma destructiva* Plow)

This is a fungous disease of both leaf and fruit which has not been reported from this state. It starts on the lower leaves, causing brown or black irregular spots which frequently unite. It causes large black spots on both green and ripe fruit but, so far as we know, cannot attack fruits which have not been injured in some way.

Leaf Mold (*Cladosporium fulvum* Cke.)

This is a fungous disease of the foliage which causes little or no trouble in the New Jersey field crops but is occasionally reported as the cause of losses in greenhouses. It appears as whitish or grayish-brown patches, which spread over the surface of the leaves, causing them to die and curl up. It also attacks the fruit, frequently causing a "blossom end rot."

It can be held in check to some extent by Bordeaux mixture, but cannot be controlled.

Blossom End or Point Rot

There has been and still is, considerable difference of opinion as to the cause of this disease. The writer is inclined to believe that it may be due to any one of several causes, but that it is most frequently due to soil and moisture conditions. In most cases that have come to our attention, we have been inclined to accept the view of other workers who have conducted experiments with this disease and who believe that it is favored by lack of moisture. However, we have demonstrated that the fungus *Botrytis* may be a cause. There is also evidence that other organisms (*Fusarium, Macrosporium, Cladosporium* and bacteria) may be the cause of the disease under some conditions.

This disease starts at the point, or blossom end, and causes large, black, sunken, soft rot spots. It is fully as prevalent on the green as on the ripe fruits.

Good soil and thorough cultivation are the only recommendations that can be made at this time.

Minor Leaf and Fruit Diseases

There are several other fungous diseases of minor importance attacking both foliage and fruit, which will not be considered at this time. Most of them can be held in check by thorough spraying with Bordeaux mixture.

Wilt or Sleeping Sickness (*Fusarium lycopersici* Sacc.)

This disease is due to a fungus which lives within the stem of the plant and causes a wilting and slow dying of the plant. On cutting the stems with a sharp knife, discolored tissue will be found just below the bark. Plants are frequently affected with this disease from the seed-bed; but are usually well advanced before they begin to die. Death usually results long before the plant has produced a full crop. This disease is very destructive in parts of New Jersey.

The fact that the organism lives within the plant makes it impossible to control the disease by spraying. Seed-beds should always be made from clean soil which has not been used for the growing of tomatoes for some time. If it is known that the disease has been in the seed-bed the previous year, all the soil should be removed and the woodwork throughly drenched with copper sulfate solution (2

Fig. 4. Wilt (photo by R. W. DeBaun)

pounds of copper sulfate in 50 gallons of water) before the new soil is put in. Do not put tomatoes in a field in which the disease has occurred without using a rotation of crops.

Another WILT OR SLEEPING SICKNESS due to bacteria (*Bacterium solanacearum* Sm.) occasionally appears in the southern part of the state. It can be recognized by the fact that the plants wilt during the day and revive during the night for two or three days and then die. It is of comparatively little importance in New Jersey.

ROOT ROTS are usually due to fungi and can be kept in control by the use of clean seed-beds and rotation of crops.

Mosaic and Filiform (cause unknown)

This disease was very prevalent in New Jersey in 1915 and in 1916, and no doubt contributed to reducing the crop. The mild forms of the disease appear as a peculiar mottling of the leaves, ranging from light green to yellow blotches. This is frequently followed by a dying of parts of the leaves and stems. This mottling is frequently accompanied by a rolling of the leaves. In more severe

Fig. 5. Mosaic and Filiform

cases we find a dwarfing of the leaf due to a notching which gives the general appearance of a fern leaf. In some cases the blade of the leaf is reduced to such an extent that there is very little remaining, other than the mid-rib and larger veins. In the most advanced cases, the plants are dwarfed and produce little or no fruit. Large, slightly affected plants will probably produce as much fruit as the healthy or normal plants.

This same, or a very similar disease, occurs on peppers, tobacco and many other plants. It is similar to but apparently different from the mosaic of the potato. There is no satisfactory method of control, but it is well known that it can be transmitted from plant to plant, and that it is frequently spread in greenhouse plantings in

this manner. It is probably spread in the field by farm implements and by insects. Studies at the New Jersey Agricultural Experiment Station indicate that it will persist from year to year in the greenhouse soil.

SHEDDING OF BLOSSOMS. This is frequently the cause of a partial or complete loss of the crop. It may be due to any one of several causes, such as excess of nitrogen fertilizer or unfavorable weather conditions.

Fig. 6. Fruit Cracks which are Favorable for Inoculation by Rot Organism

SUN BURN of the fruit is increased by the loss of foliage due to leaf blight and other foliage diseases. It not only injures the fruit, but also makes it more susceptible to the fruit rots (pages 2 and 3).

DAMPING-OFF is primarily a seed-bed disease, but sometimes attacks larger plants, especially those grown under glass. It may be due to any one of several soil fungi. These organisms thrive in manures and are frequently introduced into the seed-beds through the application of manure. They attack the young plants at the surface of the soil, causing them to wilt, fall and die very quickly.

They can be controlled, or even eradicated, by sterilizing the soil. This can be done in a number of ways, but the most common methods are the use of formaldehyde and of steam.

Formaldehyde Sterilization of the Soil

The soil should be moist and well stirred before the application. The solution should be a 4-50 [4 pounds, or pints, of 40 per cent formaldehyde (formalin) to 50 gallons of water]. This should be applied at the rate of 1 gallon to the square foot of soil surface. The solution should be applied slowly in order to insure a thorough saturation and to prevent loss by drainage. Immediately following the application, the soil should be covered with burlap, tarpaulin, old carpet, fertilizer sacks or paper, for about two days. The covering should then be removed and the soil allowed to air thoroughly for ten days or two weeks. During this period the soil should be frequently stirred thoroughly. If the soil is not aired thoroughly, the seeds may not germinate well.

Caution. Do not add manure after sterilization. Be sure that the work tools are clean. Failure to observe these precautions may result in reinfection of the soil.

Steam Sterilization of Soil

The inverted pan method is most satisfactory. The pan may be made of No. 22 galvanized sheet iron, or from pine timber. Both types are satisfactory. The dimensions for outdoor work should be 10 by 6 feet. A 15-horsepower or higher power boiler is desirable. One-inch rubber hose makes the connection between the boiler and a nipple at the center of the pan. The edges of the pan should be pushed down into the loose soil. The soil should be moist but not wet. The application should extend over one hour at about 250° F.

Spraying

The following diseases can be held in check but not absolutely controlled by spraying with Bordeaux mixture: leaf or late blight, early blight, anthracnose, and leaf mold. The wilt diseases and mosaic cannot be controlled by spraying with Bordeaux mixture.

The most generally accepted method for controlling plant diseases is by spraying with fungicides. However, spraying has not been as successful with tomatoes as with many other crops. In fact, many growers have considered tomato spraying unprofitable. This is probably due in a large measure to the fact that the machinery has not been most satisfactory, that it is difficult to cover the leaves thoroughly, that the machinery injures the plants and in some cases does more harm than good, and that most growers have not used a sufficiently large amount of the spray mixture.

Spraying Experiments—1916

In our field experiments[2] in 1916 the best results were obtained by using a 4-4-50 mixture. The first treatment was in the seed-bed and the field treatments were applied about every week or ten days, making a total of six or possibly seven applications.

The seed-bed treatments appeared to be advantageous. However, in spraying seedlings grown under glass it is advisable to use a weak mixture in order to avoid burning the foliage.

It was very evident that our early treatments, given before the appearance of the disease in the field, were of great value.

The fruit from the sprayed plants was of better growth and finer in texture than that from the unsprayed plants.

The sprayed plants were vigorous for a longer period than the unsprayed plants.

There was no evidence that the spraying influenced the period of ripening.

The 2-3-50 mixture gave good results. There was no apparent advantage in using mixtures stronger than 4-4-50.

The increased profits from spraying will vary with the cost of labor, cost of copper sulfate, thoroughness of the treatments, weather conditions and selling price of the fruit.

For preparing Bordeaux mixture see Circular 48 of the New Jersey Agricultural Experiment Station.

A complete report of this work has been published in the 1916 Report of the New Jersey Agricultural Experiment Station.

Spraying Experiments—1917

In our 1917 experiments at Riverton we used the following mixtures:

1. Bordeaux (4 pounds copper sulfate, 4 pounds lime, 50 gallons water).

2. Bordeaux plus resin fish-oil soap (4 pounds copper sulfate, 4 pounds lime, 3 pounds soap, 50 gallons water).

3. Bordeaux with a small amount of lime plus resin fish-oil soap (4 pounds copper sulfate, 2 pounds lime, 3 pounds soap, 50 gallons water).

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[2] These experiments were conducted in cooperation with the United States Bureau of Plant Industry and the H. J. Heinz Company, and were under the immediate direction of the junior author.

The results of these treatments are as follows:

(a) The highest yield was obtained with No. 1, the standard 4-4-50 Bordeaux mixture; the second highest yield with No. 2, the 4-4-3-50 mixture.

(b) The *best control* of the fungus (not highest yield) was obtained with No. 3, the 4-2-3-50 mixture; the second best control with No. 2, the 4-4-3-50 mixture; the third best control with No. 1, the 4-4-50 (standard) Bordeaux.

(c) The advantages of using the resin fish-oil soap were very evident. It caused the mixture to spread and stick much better than the ordinary Bordeaux. This was very evident on plants after a heavy rainfall. It has some slight fungicidal value.

(d) There was no foliage injury with No. 3, as is ordinarily the case when an excess of copper sulfate is used.

Preparation of the Mixtures[3]

STOCK SOLUTION. In extensive spraying it is desirable to make stock solutions which can be diluted and thus used very quickly as needed. They are as follows:

(a) *Copper sulfate solution.* Dissolve the copper sulfate by using as many gallons of water as there are pounds of copper sulfate. Use a wooden or glazed earthenware container. Put the water (soft water is best) in the container; put the copper sulfate in a cloth bag and suspend just beneath the surface of the water. The copper sulfate will dissolve readily. The solution should be well stirred with a *wooden* stick.

(b) *Milk of lime.* Use the very best grade of quick lime. Put lime in a wooden or metal container. Slake by adding small quantities of water at intervals until the lime is thoroughly crumbled. Add water to make as many gallons of milk as there were pounds of lime. Stir thoroughly both when making up the volume and each time before dipping out for use. Use quick lime if possible, but if it cannot be obtained use one and one-third times as much hydrated lime, which can be mixed immediately without slaking.

(c) *Resin fish-oil soap suspension.* Put soap in metal or wooden container. Add water slowly and stir thoroughly. Use enough water to make as many gallons of the suspension as there are pounds of the soap. Hot water is preferable to cold water.

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[3] For Standard Bordeaux mixture, see Circular 48 of the New Jersey Agricultural Experiment Station.

Mixing the Materials

Mixing can be carried on best by using a mixing platform about the height of the spray tank.

(a) For No. 1 (i. e., the 4-4-50 or Standard Bordeaux) use two barrels with spigots in the bottoms. Put 4 gallons of the copper sulfate solution in one barrel and 4 gallons of the milk of lime in the other. Add 21 gallons of water to each barrel. Open the spigots and allow the two preparations to run into a trough leading into the spray tank. The flow from the two barrels should be as nearly equal as possible. The best mixtures are made at a temperature of about 50° F.

Or, put 4 gallons of the copper sulfate solution in the spray tank, add 42 gallons of water, and then add 4 gallons of milk of lime.

Or, put 4 gallons of milk of lime in the spray tank, add 42 gallons of water, and then add 4 gallons of copper sulfate solution.

Test for Standard Bordeaux Mixture. Bordeaux mixture should always be tested before using. If insufficient lime is used in the making, or if the lime is poor in quality, the copper sulfate may be injurious to the foliage and fruit. The mixture can be tested by dropping a few drops of yellow prussiate of potash (POISON) into a glass of the mixture. If a dirty brown precipitate is formed, more lime should be used. It is not necessary to use this test with any except No. 1, the standard Bordeaux mixture.

(b) In making No. 2, proceed as in (a), except that 3 gallons less of water is used. Then add 3 gallons of the soap suspension and stir.

(c) In making No. 3, proceed as in (b), except that 44 gallons of water and only 2 gallons of the milk of lime are used.

Time of Spraying

Spraying should begin in New Jersey about July first. In the extreme southern part of the state it should begin one week earlier. The plants should be sprayed every ten days or two weeks throughout the months of July and August. Use 100 to 150 gallons of the mixture per acre and apply at a pressure of 125 to 150 pounds. Use at least three nozzles to the row; one from above directing the spray downward and one from each side directed toward the plant.

Seed-bed spraying is of very little advantage in the direct control of the fungus but is helpful in the control of insects.

Results of Spraying

(1) Sprayed plants hold their foliage longer and produce more fruit than unsprayed plants. The increase in production is during the latter half of the season. The very late fruit can be ripened after picking and very frequently brings a high price on the market.

(2) The sprayed plants have more foliage than the unsprayed plants, thus giving a better shade which prevents sun-burning and scalding of the fruit. This fruit is better in color and flavor than fruit from unsprayed plants.

NOTE

Source of Data. This circular is the result of experiments carried on during 1916 and 1917. The 1916 experiments were in cooperation with the Office of Cotton and Truck and Forage Crop Disease Investigations of the United States Bureau of Plant Industry and the H. J. Heinz Company. They were conducted near Salem, N. J., and were under the direct charge of the junior author. The 1917 tests were in cooperation with the same office and with the Campbell Soup Company, near Riverton, N. J., and were also under the direct supervision of W. H. Martin, of the State Experiment Station at New Brunswick.

OTHER PUBLICATIONS ON PLANT DISEASES

The following is a list of other publications pertaining to plant disesases and their control which have been issued by the Agricultural Experiment Station. Copies of these may be obtained free upon request.

No.

29. Peach Leaf-Curl.
48. Bordeaux Mixture.
52. Common Diseases of the Pear.
55. Common Diseases of the Grape.
63. A Substitute for Self-Boiled Lime-Sulfur and other Summer Sprays for Peaches.
68. Common Diseases of Cucumbers and Melons.
76. Spray Calendar for Pears.
77. Spray Calendar for Sweet Cherry.
78. Spray Calendar for Plum.
80. Common Diseases of Apples, Pears and Quinces.
81. Common Diseases of Peach, Plum and Cherry.
84. Common Diseases of Beans and Peas.
88. Common Diseases of Berries.
89. Common Diseases of Garden Vegetables and Truck Crops.
93. Spray Calendar for Apples and Quinces.
94. Spray Calendar for the Peach.
97. Common Diseases of Ornamental Plants.
98. Diseases of Shade and Ornamental Trees.
102. Diseases of Grains and Forage Crops.